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QUANTITATIVE DISTRIBUTION OF BOTTOM FAUNA IN THE WORLD OCEAN ABYSSAL AREAS

- USSR -

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QUANTITATIVE DISTRIBUTION OF BOTTOM FAUNA IN THE WORLD OCEAN ABYSSAL AREAS

[Following is a translation of an article by Corresponding member of the Academy of Sciences, USSR, L. A. Zenkevich, N. G. Barsanova and G. M. Belyayev published in DAN (Reports of the Acad. Sci., USSR) Oceanology, 1960, volume 130, No. 1.]

Data on the quantitative distribution of life in the oceans are of extreme importance in the development of oceanology. They are indispensable for the explanation of laws of distribution and origin of living raw materials in the ocean, for an understanding of trophic connections between organisms, for a complete characteristic of the living organisms of the halosphere as an indicator of physical processes, and for an understanding of the role of living bodies in the cycle of chemical substances of the ocean. All these phenomena require numerical expression, otherwise they would be devoid of a major part of their scientific and practical significance. It is a well known fact that living organisms possess an ability to accumulate in their bodies a variety of chemical elements, including the radioactive, in quantities a thousandfold in excess of the concentration of these elements in sea water. It is therefore of particular importance to have quantitative data on life of the products of radioactive decay in the mass of sea water, as well as of the degree and rate of contamination of the ocean with these products.

Until recently, however, science had only very skimpy data on the quantitative distribution of life in the ocean. This applies in particular to the open deep-water aquatoria which comprise more than three-fourths of the world's Ocean area. It was not an accident that a paper at the last session (September 1958) of the Special Committee for Oceanic Research SCOR) of UNESCO noted that with few exceptions it was at present impossible to make a quantita-

tive estimate of the extent of the population of sea organisms and of biological productivity within the range of the world's ocean, and it was pointed out that there was a need to develop methods of quantitative research which would make it possible to compare results.

As regards the distribution of bottom organisms in the ocean, we cannot disagree with the opinion of G. Thorson (12) on the indispensability of quantitative charting of living groups on the bottoms on the basis of a single standard research method, and on the fact that thus far such research has only been made in a few areas, mostly in the Arctic Seas and on the coasts of Western Europe. Thorson also noted that there was very little of this kind of work done in the USA thus far. We must say that this reproach is least applicable to Soviet research.

Research of fauna in all the seas of the USSR has been conducted with the aid of quantitative methods for as long as 35 years. There is an accumulation of many years' observations on a number of seas of the USSR (particularly the Barents, Azov and Caspian) on the dynamics of distribution both of benthos and plankton. During the course of the last 10 years a number of expeditions using the research ships "Vityaz'" and "OB'" obtained data on quantitative distribution of benthos not only in the seas which wash the shores of the Soviet Union, but also in the abyss of the wide aquatoria of the Pacific and Indian Ocean, and of the Antarctic waters. Thus far, only part of these data have been published concerning the Far Eastern seas and the Northwestern Pacific (1, 6-9), as well as the Antarctic (2-4).

Quantitative data on the distribution of deep-water benthos in a number of other areas were obtained only by the Danish expedition on the ship "Galathea" but they have thus far been published only concerning a small area on the West coast of tropical Africa (10) and concerning individual points of deep-water ocean depressions: the Philippine and the Banda Sea (11).

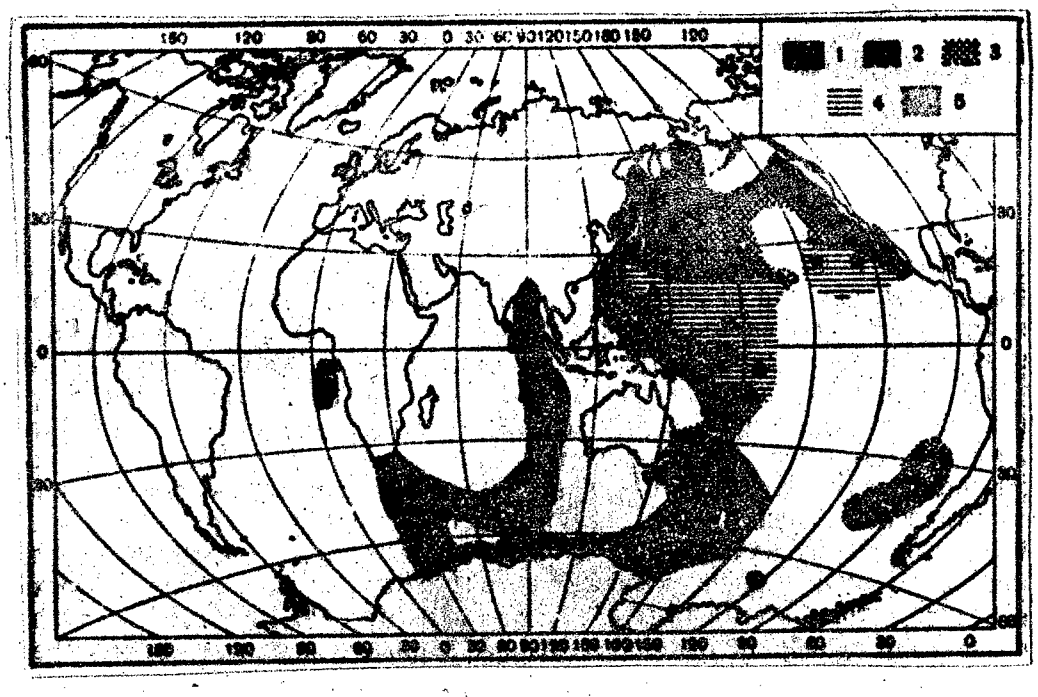

Fig. 1. The biological mass of benthos (g/m^2) at depths over 2,000 m in the Pacific and Indian Ocean, according to data of the expeditions on the ships "Vityaz'" and "OB'" and the Atlantic Ocean according to data of the "Galathea" expedition (11). 1: > 1, 2: 0.1 to 1, 3: 0.05 to 0.1, 4: 0.01 to 0.05, 5: < 0.01.

Fig. 1 contains a chart of quantitative distribution of bottom fauna in the abyssal regions of the Pacific and Indian Ocean, plotted from the data of all quantitative bottom probes obtained by the ships "Vityaz'" and "OB'" up to April 1959 inclusive, at depths over 2,000 m (more than 220 stations). This chart makes it possible to judge for the first time, if only in first approximation, the quantitative distribution of benthos in an area which comprises more than one-fourth of the entire Pacific Ocean.

As can be seen from Fig. 1, the deep-water fauna of the areas close to the shores characterize the highest indices of a quantitative abundance. The biological mass of benthos is especially high in these areas, where there is a plentiful drift of organic matter from the shore shallows into the depths. Thus, for example, at depths over 3,000 m, the biological mass of benthos constitutes the following average in a 100-mile shore zone: in the Bering Sea -- over 20 g/m^2, in the Northwestern Pacific Ocean -- over 6 g/m^2, and near the ice-covered shores of the Antarctic

continent which are very poor in life, it is only about 2 g/m^2. As we go away from the shores we observe a decrease of the quantitative abundance of bottom fauna. The bottom fauna of the abyssal areas of the open ocean (at depths over 3,000 m) is characterized by average indices of biological mass somewhat below 1 g/m^2 in the temperate and polar zones. In the Northwestern Pacific and in the subarctic and arctic waters of the Indian Ocean these indices are 0.7; 0.5 and 0.8 g/m^2, respectively.

The most life-poor regions are in the tropical zone of the open ocean, far from shore. The biological mass does not exceed 0.1 g/m^2 as a rule in these regions, and extremely expansive aquatoria are characterized by even smaller quantities -- from single [specimens] to some tens of milligrams per 1 m^2. The averaging of available data from probes of depths over 3,000 m gave quantities of 0.08 and 0.03 g/m^2 for the tropical region of the Pacific and Indian Ocean. Thus, in comparison with the off-shore shallows, in which the biological mass of benthos may reach several kilograms per 1 m^2, in the abyssal areas of the ocean regions poorest in life the quantitative abundance of a given fauna may be lower by approximately a million times. The amplitude of oscillations of the biological mass of benthos is also damped in the abyssal areas of the open ocean far from shore. In numerous regions of shallow seas and ocean shores the abundance of a given fauna varies by a factor of approximately one thousand, and on the beds of the open ocean in the tropical zone -- only by a factor of one hundred.

As regards plankton, both the change in its biological mass in the ocean depths in comparison with surface shore waters, as well as the amplitude of oscillations in the surface and deep layers is smaller than for benthos. This appears to indicate a lower degree of dependence of plankton on food resources proceeding from shores.

The above-noted quantitative impoverishment of benthos in the tropical abyssal area in comparison with the temperate and polar zones is also observed in the off-shore regions (Table 1).

Table 1

Average biological mass at depths from 1,000 to 3,000 m within the limits of a 100-mile off-shore zone

Region	Latitude	Biological mass g/m^2	Expedition
	Temperate and Polar Zone		
Bering Sea	55 - 65° N	22.6	"Vityaz'"
Eastern Kamchatka	50 - 53° N	24.3	"Vityaz'"
Kurile Islands	45 - 50° N	11.4	"Vityaz'"
Eastern Japan	35 - 41° N	87.8	"Vityaz'"
South Africa	35° S	9.9	"OB'"
South Australia	37° S	6.1	"OB'"
New Zealand (North Isl.)	35 - 42° S	28.6	"Vityaz'"
Antarctica (Indian Ocean)	60 - 70° S	5.6	"OB'"
	Tropical Zone		
Bay of Bengal	21° N	0.42	"OB'"
New Guinea	0 - 10° S	1.53	"Vityaz'"
West Africa	5 - 10° S	1.25	"Galathea" (11)
West Africa	12° S	2.70	"Galathea" (11)

As regards the qualitative composition of bottom fauna at depths of the ocean bed, Polychaeta play a dominant part in this instance. This is apparently associated first of all with a wide range of soft and mostly slimy soils at these depths. There is no doubt that foraminifera play an important part in the bottom abyssal fauna. Thus far, however, we have no quantitative data* on foraminifera due to the lack of a method which would make it possible to separate, during mass probings, the living foraminifera from their empty shells.

The data presently available on the quantitative abundance of zoobenthos in different regions of the oceans

*All data on the biological mass of benthos cited here were obtained without taking into account foraminifera.

make it possible to produce an orientational estimate of the total quantity of bottom fauna in all the oceans (Table 2). The data in Table concerning the area of the ocean bottom at various depths were borrowed from the abstract of L. A. Zenkevich (5). These data refer to the area of the ocean surface without taking into account the unevenness of the ocean bottom profile. As a result of this, the areas which are actually inhabited by bottom creatures, and correspondingly the total data on the biological mass should be somewhat higher than the figures cited in Table 2. In addition, the total mass of living matter in the shallow-water zone should be increased to a considerable degree on account of the population of the littoral zone which lies higher than zero depth and has therefore not been taken into account in the data on the ocean area. All this permits the assumption to be made that the magnitude of the total biological mass of benthos in all the oceans, of 6,660 million tons should be increased at most by a factor of one and one-half. Thus, the total mass of living bottom fauna of the oceans of the world should be expressed by a magnitude of the order of 10 billion tons or $1 \cdot 10^{10}$ t. It is

Table 2

Quantity of Bottom Fauna in the Oceans of the World

Depth, m	Area		Orientation aver. biol. mass, g/m^2 (t/km^3)	Total biol. mass	
	millions km^2	%		millions t	%
0 to 200	27.5	7.6	200	5,500	82.6
200 to 3,000	55.2	15.3	20	1,104	16.6
> 3,000	278.3	77.1	0.2	56	0.8
All the oceans	361	100	18.5	6,660	100

very significant that out of that amount more than 80% is in the off-shore shallows and only less than 1% in the abyssal depths which occupy more than three-fourths of the area of the oceans of the world.

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